# EXPERIMENTAL RESCEARCHES

ON THE

# POST-MORTEM CONTRACTILITY OF THE MUSCLES,

WITH

## OBSERVATIONS ON THE

# REFLEX THEORY.

BY

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1846.

TO PROFESSOR

CHARLES A. LEE, M.D.

AND THROUGH HIM, TO THE

MEDICAL PROFESSION

OF THE UNITED STATES,

THIS ESSAY

IS MOST RESPECTFULLY INSCRIBED,

TO THE PRESIDENT

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In carrying out the limited aim of this monograph, it is necessary to enter upon a sterile field, which has been, nevertheless, much cultivated of late by some of the most eminent medical philosophers, and, if my labors shall lead to results different from theirs, that difference will be stated with all due deference and candor, without indulging in a spirit of controversy unwarranted by the exigencies of the occasion. In matters of an unsettled or disputable nature, the collision of opinion with opinion, of argument with argument, may elicit the spark of truth to guide us into the right path.

Avoiding, as much as possible, all general observations on the anatomy, physiology, and pathology of the Nervous System, except so far as they stand related to muscular motion and the Reflex Theory, I will at once admit that the Reflex doctrine is ingenious, and has been useful in exciting inquiry, though its claims as a fundamental principle of science are, as I expect to show, altogether visionary. An entire devotion to the truth, in the examination of this subject, implies neither presumption nor temerity.

The Neologies of the Reflex system, independently of its doctrines, are alike puzzling to teacher and pupil, and foreign to the genius of both ancient and modern lexicons, and will afford the future historian of medical literature, curiosities, not to say enigmas—

> "Words so hard no stone
> Is hard enough to touch them on."

Afferent and Efferent; Ingestive, Egestive, Centric and Excentric; Excito-motor, Motor-excitor, Incident-excitor, Motor primitive fibril, Sen-

sitive primitive fibril, Motor-sensory-grey matter, Sensory-grey matter, Centrifugal and Centripetal nervous conductions, Psychical, connate, Sensori-volitional, Idea-genic, Kinetic, and other kinds of strata and substrata, with many Reflex changes acting on the histological stratifications, etc!

Whether this technology shall be planted firmly in our dictionaries, depends not so much upon the lexicographers, as upon the soundness of the doctrines which these terms represent. In more than one respect, this is a very important question. After the exploration of that immense mass of concentrated agony, which has been drawn from the sawing, pinching, pricking, cutting, burning, electrifying, and galvanizing frogs and other animals—after travelling through the labyrinthian mazes of the Reflex Physiology and Pathology, the student at the denouement is compelled to say, as in "The Two Gentlemen of Verona,"

"How like a dream is this I see and hear!"

I could name one of the best works on Physiology, wherein the Reflex doctrine, in its various phases in the nervous and muscular systems, occupies *one-sixth* of the entire book, requiring more time and difficulty to get some notion of it, and then to unlearn it, than any other part of the work, as is usually the case, where the words are hard, the experiments equivocal, the doctrines incomprehensible.

The Medico-Chirurgical Review of 1836 designates the doctrines of Bell and Hall as "a burst of discovery as brilliant as it was unexpected," and at the same time explains the excitomotory or Reflex theory thus:—"If a stimulus be applied to a part supplied and regulated by the spinal nerves, the impression is conveyed by sentient nerves to the spinal axis, and the action consequent upon it is conveyed from the spinal axis by motor nerves to the original part. All this is, to a certain degree, independent of the brain."

This able periodical, whose distinguished editor, unfortunately for the cause of science, is now numbered with the dead, has for more than twenty years upheld this doctrine in all its phases—even the last number (Oct., 1845) proclaims it "as the foundation upon which all accurate knowledge must ever repose." The following extracts are from the same work:

"It is at length admitted on all hands that here (in the spinal cord) impressions do pass, and necessarily, from the afferent to the efferent fibres.' 'The impression (necessary to muscular motion) is conducted to the spinal marrow, is thence reflected, and again reaches either the part on which the impression took place, or some other part remote from it, where the muscular contractions now take place'—'*in an arched and reflected course, requiring that the connection with the spinal marrow be uninjured*'—'a throwing back of the nervous principle into the spinal marrow, without at the same time admitting a process similar to sensation.' This process is also compared to the '*reflection of light.*'"

To prevent mistakes as to the meaning of authors, it will be necessary to give their own words, as briefly as possible, on this topic. Dr. M. Hall, in his work on the *Nervous System*, says that he "divided the spinal marrow of a frog below the occiput—on pinching its toes with the forceps, the extremities moved," but "on destroying the spinal marrow with a probe, they were, on pinching, motionless." "The limbs of an

animal, or a part of an animal, separated from the influence of the cere brum, become relaxed on destroying the spinal marrow." "On withdrawing gently the spinal marrow of a decapitated turtle, all motion ceased. The limbs were no longer obedient to stimuli, became perfectly flaccid, having lost all their resilience. The sphincter lost its circular form and contracted state, and became lax, flaccid, and shapeless." "*The presence of the Medulla Oblongata and Spinalis is necessary to the contractile function.*" "To irritate the spinal nerves will produce contractions the very type of tetanus, leaving no doubt of what particular part of the nervous system is affected in that disease." Finally, he concludes, that these "effects have not been hitherto suspected by Physiologists."

In an able and approbatory review of this work (American Jour. Med. Science, 1839), a summary of Dr. Hall's discovery is thus given: "five circumstances are required in every instance of an excito-motory act; an excitant; *an excitor nerve, continuous to the nervous centre; the integrity of that centre: a motor nerve, continuous to the muscle to be excited into contraction;* and that muscle to be endowed with perfect irritability. *If any part of the arc be interrupted, the phenomena cease instantly.*" "There can be no better test of the value of these views than the contest which has arisen, not with regard to their truth, but their originality"—"they have gained ground in despite of all opposition." "*All action is the result of stimuli to the nerves which proceed to the spinal marrow, pursuing a reflex course,*"—"*By two lines.*" Reflex, convex, complex, and perplexing routes these, for even Bell, Hall, Müller, Magendie, and both the *Academies Royales!*

The reviewer refers to a frog, a turtle, and a lobster experiment by Dr. H. To make an experiment under the tension of a preconceived theory, is, too often, but little better than the making of an experiment to order. According to the reflexians the destruction of any part of the cord affects the contractility of a corresponding part of the body and no more! This is what Mr. Canning called drawing on the imagination for facts.

In the Philosophical Transactions (1839), Dr. H. advances the same doctrine—"*That muscular contraction is reflex, curved,—requiring the connection with the medulla spinalis to be preserved entire.*"

In order to investigate this subject in a proper manner, that is rigorously and without bias, it is necessary to forget the great names which stand committed to the doctrine of Bell. Many years before his death he declared that "the reception of his discovery, concerning the different functions of the anterior and posterior roots of the nerves, was the reverse of what he expected, its early announcement having failed to draw one encouraging sentence from medical men." (Nerv. Syst., p. 10.) What a change! In January, 1845, when M. Castel presented to the Royal Academy of Medicine, at Paris, his work on the *nervous system*, purporting to be a refutation of this doctrine of Bell* (*Exposition des attributs du Système Nerveux, refutation de la doc-*

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* M. Bosquet's review of this work in the *Gaz. Méd. de Paris*, might be best translated by a slight change in Pope's epitaph on Newton, thus:

"Nature and nature's laws lay hid in night."

God said, "Let Castel be!" and all was light: or as M. B. says, "*Sans lui, tout*

*trine de Charles Bell, etc.*), he was gravely charged with being the only member of that learned institution who denied this fundamental doctrine of neurology. Impartial history teaches us not to be surprised at anything which relates to the oscillations of medical theory. Dr. Marshall Hall, who has lately received the well-merited honor of membership in the Academy, is more fortunate than Bell, since he sees his reflex doctrine flourishing almost everywhere in insular and continental Europe.

However desirable it may be to avoid uttering common-place homilies on the nervous system, it is necessary to give, briefly as perspicuity will allow, the views of the most prominent writers on the subject under consideration.

The reflex school maintains, not only that the integrity of the spinal cord is indispensable to transmission, but that the division of the anterior roots is a complete barrier to muscular motion. This doctrine is not based on the healthy, living body. It is not, with a few obscure and unimportant exceptions, deduced from morbid conditions, but from the last agony, and more than all, from the recently dead state of the inferior animals—a kind of proof by no means satisfactory.

It should never be forgotten that experiments on the inferior animals, as frogs and turtles, are inconclusive in establishing the complicated physiology of man. An earth-worm may be cut into several pieces, each of which becomes a perfect animal. The more the *hydræ* are subdivided, the more is their number increased without loss of vitality. Could we deduce a vital or reflex theory from such experiments applicable to man? Were capital punishment changed from hanging to vivisection of the spinal marrow, this would but poorly illustrate the physiology of a healthy man, or the pathology of a sick one, yet one such experiment would be worth a thousand upon frogs.

I beg leave to offer an example, not perhaps the most striking, but the most convenient, taken from "Blackwood's Magazine," showing the vitality of the shark (reported in a work "*Fifty days on board a slave vessel, in* 1843," by the Rev. P. G. Grenfell, chaplain on board H.B.M. ship Cleopatra) :—

"A shark followed the ship and was caught. When brought on deck he exhibited the usual and remarkable tenacity of life. Though the tail was chopped off and his entrails taken out, in neither of which operations it exhibited any signs of sensation, yet no sooner was a bucket of salt water poured on it to wash the deck, than it began to flounder about and bite on all sides."

Does man ever exhibit such vivid phenomena after evisceration?

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*est obscurité, tout est confusion; avec lui, tout se dénoue, tout s'explique, et les ténèbres font place à la lumière.*" M. Castel delivers himself of his general doctrine thus, "*La myotilité exige un plus grand somme de puissance nerveuse que la sensibilité.* He maintains that the only difference between the anterior and posterior roots consists in the different degrees of consistence or density by which their conducting power is modified; that the anterior roots have more motor force, because they are denser, and, therefore, better galvanic conductors. Now without affirming or denying M. Castel's doctrine, I must protest against the principle of building one half physiology and pathology upon the conducting powers of zinc, copper, nerves and muscles. This superior conduction of the anterior roots may refute the doctrine of Bell, but still it leaves us in that *terra incognita* (or *terra nervosa*, it might be called), where Bell struggled all his life along the frontiers of galvanism and vitalism—where reason as well as electricity itself, cast an uncertain and bewildering light, and where an invisible barrier arrests the progress of the human faculties. In this nebulous realm, this Hades of physiology, the reflex magicians build their phantasmagorial system.

Hear Sir Charles Bell, in his great work on the nervous system :—

" Cold-blooded animals will live without the brain. Birds, whose heads were cut off, Le Gallois says, walked, seemed to feel pain, and moved their feet towards the part. Flourens goes further, since he says, that a bird deprived of the cerebral lobes dressed its feathers, and ran and leaped."—P. 25.

Such experiments, including many of the author's prickings and cuttings of the spinal marrow, can have no satisfactory application to man. The same may be said of M. Magendie's experiments.* He wishes to know the functions of certain nerves; he divides them at their origin, plunging a sharp instrument through both sides of the skull at the base of the brain, cutting up the cerebral matter, and perhaps several other nerves, in order to divide the fifth ; nay, more, he removes both hemispheres of the brain from a duck. This animal, for eight days after, appeared to do very well, and as he assures us, possessed the sense of smell ! Now the question is, does man exhibit such phenomena after the removal of the brain, or the division of its nerves within the cranium, or the dissection of the anterior and posterior roots of the spinal nerves ? Truly, the reflex theory is well named (from, as I suppose, *reflecto*, to bend or bow back, to recurve). Its logic is angular, curved, or circular, as well as the experiments themselves !

I do not here wish to dwell on the equivocal results obtained from artificial tortures, and artificial diseased conditions of a denaturalizing character, so completely beyond the pale of normal physiology and pathology, and, withal, based, on experiments difficult to execute, and repulsive to the moral sense of the profession ; experiments not likely to be verified for these reasons, though the obscurity of the subject would seem to require a proportional multiplicity of observations.

As illustrative of the nature of these experiments, I offer the testimony of an able champion of the reflex school :—" The experiments," says the editor of the ' Medico-Chirurgical Review,' " which have been devised and practised for ascertaining the functions of the nerves, are the most cruel that can be imagined, while the results thereby obtained have frequently been unconvincing or uncertain." This language, repeated from year to year, gathers strength in the last number of that journal (Oct., 1845), in which the editor denounces vivisections, and " protests," to use his own words, " against those barbarous experiments on living animals, the performance of which is so disgraceful, upon the whole, to the medical profession. And what good have they done ?—literally none. We verily believe that there would have been much more rational views upon many disputed questions in physiology, if observation had been exclusively confined to noticing the natural and spontaneous phenomena of life in health and disease, and diligently examining after death the effects which disease leaves behind. Shall we believe that any conclusion worth knowing can be drawn from cutting a poor animal's heart out of its body ? Away with such butcher-like philosophy !" Subtract these experiments from the reflex theory and little remains !

Without at all derogating from Sir Charles Bell's, or M. Magendie's, or Dr. Hall's claims as discoverers of the " anterior roots," and reflex theories built thereupon, it may be proper to add that Haller maintains the spinal theory of muscular contraction, which, he asserts is rendered impossible by the destruction of the spinal cord " (*First Lines*, ccccii.)."

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* English critics assign to this distinguished physiologist, the second seat of honor in this department of discovery.

Béclard says, "That the conditions of muscular action are, the life of the muscle and its communication with the circulatory and nervous centre, its integral state, and the action of an exciting or stimulating influence;" he adds, "That cadaveric rigidity never takes place so long as the muscles possess any galvanic irritability.—(*Gen. Anat.*) Hooper holds that, "To a certainty no muscular contraction can take place without the immediate action of the brain and nerves."—(*Dict. Méd.*) Sometimes he represents contractility as the fundamental property of vitality, and even as its cause. In a late and learned work on Physiological Anatomy and Physiology, by Messrs. Todd & Bowman, the reflex theory appears as a fundamental truth; "The antero-lateral columns of the cord, with the anterior and posterior forms of the grey matter, are the effective centres of motion and sensation to the trunk and extremities."

Sir Charles Bell sums up his researches upon this subject, by saying, "These opinions and experiments have been followed up to the satisfaction of all Europe. It has been acknowledged that the anterior roots of the spinal nerves bestow the power of muscular motion and the posterior sensibility."—(*Anat.*) A discovery which Dr. M. Hall designates "as the most splendid in physiology within the last century."—(*Diag.*)

Professor Carpenter, of England (who considers the spinal marrow as not only independent of the brain, but as frequently opposed to it in action), when speaking of the biceps muscle, says, "That the only way to excite the whole muscle into contraction at once, is to stimulate it through its nerves."—(*Phys.*) Many other authors flatly deny the possibility of exciting contractions when the nerves leading to the muscles in the recently dead body are divided. "The power of determining individual muscular action involves of necessity the agency of insulated, that is, independent conductors."—(*Med. Chir. Rev., Oct.*, 1845.)

Before entering upon the validity of these assumptions it may be proper to state that the circle of the reflex function is rapidly extending from the spinal marrow to the brain, where the phrenologists find it very useful in explaining the developments. Geo. Combe, Esq., infers, "that from the anterior lobes of the brain, the seat of the intellectual faculties, there must be medullary fibres communicating with the motor portion of the spinal cord." Professor Reid, after saying "that the true excito-motory movements do not require the presence of the cerebrum for their manifestation," adds, "All modern physiologists agree that when emotions are excited in the mind, a reflex and motive influence is sent downwards along the motiferous column, and along the motor nerves, to the muscles thrown into contraction." Dr. Laycock carries the reflex doctrine further, and to make it the basis of all mental science, "All incident excitor impressions have to complete a circle through the central ganglia of the cerebro-spinal axis,"—"exciting ideagenic and kientic substrata, and the organs of intellect, and the desire for medical skill and other phenomena of reason and volition; the deepest feelings of religion, patriotism and honor; the love and pursuit of truth; the avoidance of evil, and all moral incentives to actions whatsoever,"—"which have substrata upon which incident excitor impressions impinge, and from which motor impulses may be derived. The impulse in traversing the ideagenic substrata changes the other substrata, in a series; sensations and ideas arise, and new substrata are formed; psychical substrata are formed according to the division of the grey matter. The energy of the muscu-

lar act, will depend upon the excitability of the grey matter at the point of reflex cerebral action and upon the extent of affinities between the impinging impression and the recipient substrata. The size and motor force of an organ will be in proportion to the number and strength or quality of its ideagenic substrata." Dr. L. speaks of these strata as being dislocated!—(*Vide Lond. Lancet, Aug.*, 1845.) The language, the doctrines, and the complex apparatus concerned in this reflex explanation, are alike incomprehensible and suspicious.

This jargon daily increases, though, as yet, it is chiefly endemic to Europe.* Everything is becoming reflex, not excepting generation! We read of reflex nutrition, reflex development, reflex remedies; strychnia travels along the motoriferous tract, while morphia takes up the line of march along the sensiferous. This great double railway the phrenologists, as above-mentioned, have ably extended to the encephalon, where it would seem the terminus is to be located, among the psychical strata and substrata. In plain English, the brain, composed as it is of albumen, phosphorus, water, &c., becomes afferent, efferent, reflex, and if need be, perhaps, circular too.

Not content that the anterior roots shall preside over motion and the posterior over sensation, according to Bell and Magendie; not content with Dr. Hall's addition, which is supposed to explain these functions, the advocates of this doctrine threaten to absorb much of physiology and pathology, together with the whole of mental science. Dr. Laycock says (*London Lancet, Sept.*, 1845), no mental phenomena whatever are exempt from the laws of reflex action. By the term psychical substratum, I mean a material substratum—a definite arrangement of matter, &c.; contractility "in a decapitated frog" (The frog! the frog!) "is excited by a substratum in the spinal ganglia." To dwell in this region of mental geology, among the "*psychical strata possessing a definite material arrangement*" (mark it! the mind material! indefinite strata, like the coats of an onion!) is foreign to our present purpose.

The theory of muscular contractility connects itself with sundry vital, chemical, and electrical speculations, which, if not more justly founded, possess a wider range than the anterior roots of the spinal column. Bichât, like Abernethy, refers contractility to life alone; to have life is the only condition necessary to muscular contraction, which latter is the effect of an active vitality.—(*Researches on Life and Death.*) Professor Draper, of New York, in his beautiful work on the chemistry of plants, denies a vital force *per se*, while Broussais regards contractility as a fundamental property of life, if not life itself; even sensibility is, according to him, one of the results of contractile movements.—(*Path.*, 104 and 64.) Professor Harrison, of New Orleans, explains muscular motion and life also, as chemical actions: "From some unknown combination of circumstances that occurred in lost geological eras, carbon united with water, organic matter was formed from inorganic, and life commenced."—(*Nerv. Syst.*, p. 200.) It will be seen in the sequel, whether non-vital and chemical theories will explain all.

The electric theory of life and contractility has, in a great degree, overshadowed all others. Professor H. M. Edwards, says, "Electric cur-

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* Dr. Gregory, in his beautiful Introductory Lecture (Oct. 1, 1845—*Med. Times*), says, "The functions of the nervous system, direct and reflex, are now slowly developing themselves."

rents act upon the muscles in the same manner as the nervous influence, and which it plausibly explains."—(*Anat. and Phys.*) Indeed, Dr. W. Philip says these fluids are identical, while M. Matteucci, in his late prize essay on this subject, wholly denies the existence of these electric fluids or currents in the nerves, and maintains that all electrical actions in the body, are not the causes but effects of vital changes. According to M. De Manneville (*Précis, etc.*), and Dr. Searle (*London Lancet*), life is but the sum of electricity. Dr. S. Dickson, of London, asserts, that "Life is electricity in its highest sense, it produces all the changes in the living body, the brain and nervous system being the electric apparatus; the nerves, the moving powers. A remedy is a repulsive or attractive force, and acts by an electric vital affinity solely." But, according to him, "*Medicina non agit in cadaver.*" "Bark is a motive power." It might be urged that the motive power in post-mortem contractility is quicker than bark, and slower than electricity.

Haller was aware of the influence of the spinal cord of certain animals over the muscles, when under galvanic excitation, or when pricked with a sharp knife, though he does not refer to the posterior roots.—(*Phys.*, ccccciii.)

I know not that the spinal marrow in the human subject has ever been tested in the living state, by pricking or scratching; and, as to exciting contractions in this manner in the dead body, *credat Judæus!* In the examination of the spinal cord of many subjects, only a few minutes after death, not a case of contraction was seen, though, in the ordinary method of cutting, chiselling, and sawing on each side of the spinous processes of the vertebræ, all the roots of the spinal nerves, as they escape from the bony canal, must be irritated in every possible way by pricking, scratching, bruising, pinching and dividing. Haller, and, I believe, all the electricians who have since his day experimented on this matter, constantly speak of convulsions being produced in the muscles. Now, a quivering, oscillating, agitated, irregular, or convulsed motion, is very different from regular intermitting extensions, pronations, supinations, which, in truth, simulate voluntary movements; of which we will say more hereafter.

The "Medico-Chirurgical Review" gives the following account of the recent experiments of MM. Longet and Matteucci, who describe the effects of electricity on the posterior or sensitive roots of the spinal cord:—

"When these were separated from the cord, no contractions were excited by the electrical current, whatever its direction. But when they were still adherent to the medulla, they always gave rise to convulsive shocks on closure of the circuit, whether the current was inverse or direct. It was evident, however, that these convulsions were owing entirely to a reflex action on the anterior roots; for, when the latter were cut across, all contractions instantly ceased. An interesting point, which their researches have elucidated, is the function of the anterior columns of the spinal cord, which are shown to possess an exclusively motor function."

I find, on referring to the transactions of the Academy, that M. Matteucci's paper on "Galvanic muscular currents" (*sur les courans galvaniques musculaires*), is founded on observations upon frogs continued from day to day for five months. These frogs were all taken from the same pond; some were killed to ascertain the contractile function—(*pour en*

*mesurer le courant musculaire*) ; others were exposed to different temperatures and gases. His grand conclusion from the whole is, that the muscular current is proportioned to the activity of the respiration ! At best, this is only a piece of frog physiology, that may not have anything to do with human physiology. Nothing in the history of fashion can be more extraordinary than the *penchant* of physiologists for that ugly, amphibious animal, the frog, so unlike man in its structure, respiration, circulation, temperature, and maladies ; yet it seems to be the type for all things concerning human beings, not excepting inflammation and muscular contraction. Why not include gout, consumption, cholera, and mesmerism ? The sacred Ibis was never so honored by the Egyptians as is this ranine amphibium, by the *savans* of our day. As this great idol of experimenters is capable of living at the bottom of a frozen pond or lake during half the year, and may be skinned, nay, decapitated without losing the power of locomotion for a considerable time ; it must be admitted that its vital versatility is well adapted to prove almost anything, especially when aided by a few assumptions and manipulations of a galvano-neurological character !

The sequel will show the infinite superiority of the motor power of a slight blow with the operator's hand, compared with all this mummery of electrical batteries, with the anterior roots of the spinal marrow of the dead and dying frogs. Will any candid man pretend that the convulsions excited among the muscles by such an overpowering agent as electricity, which shivers in an instant the mightiest oak of the forest, are at all like those repeated, intermitting, deliberate, lifelike flexions, extensions, pronations, and supinations, not complicated with horrible vivisections as described in the following pages ? Is it warrantable, is it praiseworthy to resort to the very worst kind of proof in preference to the very best, to complicate that which is simple, and to reason reflexively instead of directly ?

Bichât could not excite contractions of the heart, nor of the other organs of organic life, by electricity, though he experimented upon criminals freshly decapitated, the most favorable subjects imaginable ! In subjects but a few minutes dead from fevers and other maladies, blows, pressure, scratches, and pricks, are equally powerless in exciting these very organs, which, in the language of Haller, "are exceedingly tenacious of their *vis insita*" (ccccii.). Where is the proof that galvanic electricity has ever caused the regular systole and diastole of the heart, or the peristaltic movements of the intestines, even in the inferior animals simulating physiological action ? Far from being identical with, is it not opposed to life ? The heart of some of the inferior animals when removed from the body acts somewhat in its physiological character as an involuntary muscle for a long period, without a galvanic battery, and without "acrimonious" agents, as Haller would say, blood, water, or air alone being necessary.

Passing by John Hunter's assertion, "that the muscle can as little relax as it can contract after death," we come again to the *vis insita* of the illustrious Haller ; an assumption or hypothesis which the researches of nearly a century have not surpassed for ingenuity. "The *vis insita* is," according to him, "peculiar to life, and the first few hours after death (*First Lines Phys.*, cccc.) ; it may be excited (it is Haller who speaks) by a sharp instrument, and in the hollow muscles by air, water, and every kind of acrimony, but most powerfully by electricity ;

it is peculiarly active in the heart, stomach, and bowels."—(ccccii.) It is, I repeat, not a little remarkable, that these are the very organs in which Bichât never could excite any motion whatever by galvanic electricity. During the Reign of Terror the guillotined were delivered to him by the authorities, in from 30 to 40 minutes after execution; yet, he declares that in some every kind of mobility was extinct, and that in none could the organs of organic life be excited. He, therefore, concludes, "that with respect to galvanic phenomena, as in all others, there is a wide difference between the muscles of animal and those of organic life."—(*Res. on Life and Death.*) A conclusion which all my experiments in percussion seem to confirm. In the human subject, I have, frequently, in a few minutes after death, compressed the heart *in situ* with the hand for a moment, and then relaxing and compressing alternately, but always without producing any motions analogous to that concerned in the circulation. I do not consider that the salient but delicate ridge or elevation in the tract of a scratch or prick as possessing this character. This view is deemed very important. The muscular fibres of the heart belong, in this respect, to the muscles of animal life, a distinction that has not been adverted to even by Bichât, nor others, so far as I recollect. The heart, in its great leading function as a muscle of organic life, cannot, strictly speaking, so far as I have seen, be made to contract by a blow or a prick, though I cannot speak of frogs. When the wavy line which rises from a scratch is called a contraction of the heart, the reader is almost sure to receive a wrong impression. The "signal experiment made with the scratch of a needle in the heart by Dr. Fordyce," quoted by Dr. Dunglison, in his valuable work on physiology, should be understood as causing contractions of the muscular tissue at the point of contact only. In this case, however, the meaning is scarcely ambiguous.

Haller's experiments, without doubt, were made on the inferior animals; Bichât's were made on man; so were mine. In many robust individuals, opened in less than half the time after death designated by Bichât, I have never seen a fact which in the remotest degree confirmed Haller's doctrine, namely, that the *vis insita* is peculiarly active in the heart, stomach and bowels. In not a few of these subjects, I have the best reason for supposing that the capillary circulation was still active. The functional contractility of the human heart, the *vis insita* of Haller, is believed to be visionary in the cadaver, though this organ is susceptible to the contraction which I have described.

Whether these experiments be of any value or not, I trust that candid men will not estimate them the less when I say that they were made, not to order, but rather incidentally, while engaged in pathological inquiries which occupied my attention almost entirely. For nearly two years after I first noticed post-mortem muscular contractility, I seldom thought of its special application to the reflex theory. I viewed it as a curious, and, so far as I knew, an original observation. During an attempt to produce contusions on the recently dead body, I happened to select a spot over the middle of the biceps; a blow there (the arm having been extended on the floor) caused the subject to slap his hand against his face with much force. I was almost as much surprised as was a black man that I hired to aid me in a private dissection, in St. John the Baptist street, in 1842, of the body of a gentleman of much travel, who died of remittent fever. Previous to this dissection, which

was two hours after death, I struck the arm with the inferior edge of my extended hand. The subject contracted his arm, carrying his hand to his breast. My aid looked to the door, which had been closed beforehand, and begged to be let out without delay.

It was, therefore, very recently that I began to regard contraction thus excited in its most elementary character, as an important point of departure in the analysis of some of the most interesting problems in physiology,&c. It cannot be repeated too often, that the simplicity of a method is a great recommendation, while complexity gives rise to suspicion when an explanation is offered, and at the same time, increases the chances of error. Professor Liebig has said with much force, that "if a method of investigation bear in any degree the stamp of perfection, the result may always be given in a few words; but these few words are eternal truths."

I take for granted, until the contrary is established by experiment, that the reader will admit as true the facts set forth in this monograph. It may be asked, however, whether these facts are new? I know that certain men declare that there is nothing new in medical science. Let such read Jeremy Bentham.*

*What does Sir Charles Bell say of the muscular motions which he excited, and upon which, he, more than on anything else, founds his great discovery*—if such it be? I say nothing of the kind of animals upon which he experimented; nothing about his knocking them half dead by blows on the occiput; nothing of the complex and uncertain character of a dissection of the spinal cord of an animal which might have been dead or alive, for aught we know. His own account shows what kind of contractions his experiments produced. In his work on the nervous system, he quotes with approval, M. C. Hawkins's account of these experiments, "which," as he says, "show that when the anterior roots were pinched by the forceps, or pricked by the scissors, an evident motion was produced, perceptible to the eye;" he even goes on to insist that this was something more than "the slight tremulous motion from the natural irritability still remaining in the muscles." It is most evident that he never dreamt of regular, periodical flexions and extensions of entire limbs loaded down with heavy weights. His *experimentum crucis* on the motor

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* "Wisdom of ancestors," says Bentham, "is a Chinese argument. The reigning prejudice in favor of the dead lies not very deep—a dead man has no rivals—to nobody is he an object of envy,—in whosesoever way he may have stood when living, when dead he no longer stands in anybody's way. If he was a man of genius, those who denied him any merit during his life, even his very enemies, changing their tune all at once, assume an air of justice and kindness which costs them nothing, and enables them under pretence of respect for the dead to gratify malignity to the living. Another class habitually exalts the past for the purpose of depressing and discouraging the present generation." "You may turn over whole volumes of antiquity without discovering a solitary truth to make amends for your pains. For ten propositions evidently false, and ten times the number of unintelligible ones, you will scarcely find a single one that is true. A preference for the ancients is a most pernicious prejudice, reversing the whole order of nature. The acorn must be larger than the oak it will become. A man must be wiser in his mother's womb, than in the vigor of manhood. Everything must grow backwards. New experiments added to the subsisting stock must lessen the number. It is scarcely possible to believe a man to stand *bonâ fide* on so noxious a system. If he do, grieve over him, but treat him as an enemy to knowledge and to that happiness which is founded upon knowledge. The public interests require that his notions rise not into credit."—*Bentham's Book of Fallacies; Deontology.*

roots caused a motion "merely perceptible to the eye." This was the *ne plus ultra* of *that muscular contraction* which he could excite by pricking and pinching, under circumstances presenting the maximum of uncertainty.*

Has muscular contraction, by the percussional method, ever been pointed out by authors? Have they noted contractions without any shortening of the muscle, though accompanied with an enormous augmentation of volume and density at the points of contact? Have they ascertained, fixed, and made known the laws of muscular action, as developed by this most definite and simple of all methods, divested as it is of volition and all psychological phenomena? Have they described a case of complete motion of the whole limb, not only including flexion, but extension, pronation, supination,—in a word, all the elementary, physiological actions, simulating the voluntary movements, though less varied and more slow; but, more than all, have they illustrated the great law of contractile periodicity, excited *per se*, in a manner very different from the unmeaning convulsions of electrical action,—from the unmeaning action of a "scratch or prick with a sharp instrument?"—I say unmeaning, because no definite actions are produced resembling those called physiological. The use of the phrase "sharp instrument," from Haller's time to the present, speaks volumes in favor of my position,—for a dull instrument, as a shingle, cane, the flat side of a hatchet, or the operator's hand, is infinitely better, because it moves the entire limb, whereas, a scratch causes nothing of the kind, giving rise to nothing but a delicate ridge or line, like a thread, in any direction across a muscle, diagonally, triangularly, or in curves, as the case may be.

It is not, then, the silence of authors upon which the greatest reliance is to be placed, in claiming for this method of investigating muscular contraction, something of originality. All writers, so far as recollected, especially writers on Medical Jurisprudence, in treating of the signs of the certainty of death, rely much on muscular contraction, or as I should say, on its absence, as the most indubitable sort of proof. During the present year, M. Cadet De Grassicourt, a French writer, proposed, as the best method of ascertaining the reality of the supposed death, to dissect down to the muscles and prick them—a common recommendation in such cases,—"As if a man be dissected to see what part was disaffected," and this, perhaps, during his lifetime! (I regret that I cannot stop here to examine into the fallacy of this TEST, which would go to prove the absence of real death, or the possibility of resuscitation after

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* Few foreign authors have been so much venerated among Americans as C. Bell, though this *discovery*, so called, contributed little to this end; so of Dr. Hall. To speak of one so estimable as Bell, who has instructed and delighted us all, in any other way than that of eulogy, may not be without some risk of giving offence now that he is numbered with the dead, while his doctrine on which he spent much of his life is in the ascendant. In a communication in the "Med. Chir Rev.," Jan., 1834, relating to M. Müller's experiments, confirmatory of Sir Charles' discovery, he even labors to depreciate experiments, and prefers "to build on *anatomy*"—prefers "the *vital powers* to the *galvanic* conducting powers of the nerve." Now, all this may be very true, but is very fatal to his own experiments, since mere anatomy explains nothing of the supposed functions of the roots, anterior or posterior. It is not so surpristng that this doctrine, so founded, "was not received," as he himself assures us, "with some show of interest." Its present success is still more puzzling.

the removal of the brain, spinal marrow, the viscera of the chest and abdomen, and the amputation of the limbs, at from six to eight or fourteen hours after death!) Now, as percussion is the only perfect and safe method of exciting contractions, I cannot suppose that there is a single medical man, who, knowing this, would lay bare, by a surgical operation, the muscles of a person supposed to be possibly alive, in order to apply a test of little or no value, when one of the greatest value could be commanded by a simple blow of the inferior edge of the operator's extended hand, insufficient in force to injure a living person. Here, as in law, the rule should be that the best evidence ought to be procured.

During the last ten years, many French authors, candidates for the prize founded by Professor Manni, of the University of Rome, to be awarded by the French Academy of Sciences, have written ably upon the signs of apparent and absolute death, with a view to prevent premature interment, etc. In this question, which is still open and undecided, much importance is constantly attached to contractility, or rather to its absence, requiring a dissection in order to expose the muscles for this test! It is, in fact, a fundamental point which is made paramount to all other signs of death anterior to putrefaction. The celebrated "Nysten recommends this as a certain criterion of death—to lay bare the muscle and prick it, or apply the galvanic or electric fluid." (*Prof. Guy's Med. Juris., by Prof. Lee*, 1845, p. 372, *et seq.**) These, though negative proofs, are nevertheless sufficient to show that the method I have adopted to excite muscular contraction is wholly unknown, or absurdly rejected. Why should a very simple matter (I ask once more) be thus complicated by galvanic experiments, dissections, and reflex logic, seeing that a blow direct with the hand will produce results more definite, more like the acts of vitality and volition? If an arm, from six to fourteen hours after death—hours after the dissection of the body, and after being severed from the trunk at the shoulder-joint, contract with the utmost precision, how can gentlemen say "that the anterior columns of the spinal cord possess an exclusive motor function"? Whatever agency these roots may have when galvanized, they are incomparably inferior to the motor power of the muscle when excited by the hand, the hatchet, or a cane. A hand, or a hatchet, or a cane-theory, ought to have the preference over the reflex theory, as the former is not only the most simple, but the most scientific, affording a nearer approximation to the known physiological functions of man. Of this, the sequel will afford evidence—evidence which was scarcely sought for, but which came of itself, incidentally—evidence, simple, plain, and direct, and not obtained under the tension of any theory whatever.

My experiments, though very numerous, might have been multiplied threefold; they are already sufficiently unwieldy, and do not easily admit of analysis. I will, therefore, give a few cases taken almost at random, as found among several thousand folio MS. pages, nearly all being yellow fever subjects, which are incomparably the best for study-

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* This work contains an enumeration of the signs of death, which, with the other topics treated of, are more clearly and compendiously stated, than in any work I have seen from the foreign press. Dr. T. E. Beatty (*Cyc. Prac. Med.*) maintains that "Galvanism is the best test of the reality of death; for, if the muscular fibre do not obey it, there can be no doubt that vitality is extinguished." Galvanic contraction is no proof of the presence of life, or of the possibility of resuscitation.

ing post-mortem contractility. It is more than probable that my most striking cases are omitted, as, at the time of making the observations, I did not fully appreciate their importance. I have omitted all cases not particularly described, that is, such as were mentioned in such general terms, as "*contractile*," "*contraction active*," "*strong contractility*," &c. This I now regret, as well as the omission of many experiments which I could name, but most of all, such as might illustrate the almost incredible doctrine of counter-contraction, which, in despite of my notes, I would like to reconfirm upon a larger scale.

*Miscellaneous cases illustrative of the general phenomena of post-mortem Contractility :—*

Case I.—O. D., an Englishman, aged 26. From fifteen minutes to several hours after death, raised his fore-arm to the perpendicular as often as its flexors were struck; the motion was slow, the ratio of contraction and relaxation appeared uniform, occupying about half a minute.

Case II.—E. M., an Englishman, aged 37. At thirty minutes after death, afforded similar results. The experiments were often repeated, at prolonged periods; the contractions and relaxations were supposed to occupy about 30 seconds each. The flexion ceased at the perpendicular in every instance. When the experiments ceased, the muscular force continued at its maximum, having lost nothing.

Case III.—O. S., an Englishman, aged 27. Like the last.

Case IV.—W. O., an Englishman, aged 27. Dead five hours; neck moderately stiff; brain, 93°; epigastrium, 100°; chest, 93°; thigh, 99°. The arms strongly contractile, but the motion was slow and uniform, requiring several seconds to produce flexion and relaxation.

Case V.—H. O., a German, aged 32. Presented one hour after death active muscular contractions of the arms, which soon disappeared after a few blows, the neck being stiff; other parts flexible.

Case VI.—J. Q., a German, aged 24. Fifteen minutes to one hour after death, everywhere flexible; powerful muscular contractions; the neck became stiff; the legs and arms soon after.

Case VII.—S. G., a New Yorker, aged 22. Precisely like the last case.

Case VIII.—J. M., a Virginian, aged 31. Like the last.

Case IX.—J. R., a Marylander, aged 25. Was observed for one hour after death, during which time the biceps at intervals contracted vigorously.

Case X.—D. H., a German, aged 22. For more than an hour after death, carried his hand to his nipple as often as the extensors were struck—the jaws being rigid; 109° to 106°, for two hours.

Case XI.—Miss S., aged 26. An hour after death presented slight rigidity of the arm; one was extended; a blow caused it to rise quickly to the perpendicular, from which it slowly returned, requiring many seconds, perhaps a minute or two. Three similar operations destroyed the contractility. The fingers soon became stiff, then the arms, next the legs, but the neck was limber for three hours. The heat generally 107°, descended in the axilla, at four hours after death, to 103½°.

Case XII.—F. L., a Frenchman, aged 58. Dead about one hour; heat 107½° to 103°; possessed the contractile function strongly, carry-

ing the hand to the breast; also performing pronation and supination according to the percussion. The abdominal muscles were rigid.

Case XIII.—This subject had been dead two hours; he lifted his arm quickly and often, several feet from the table, sometimes striking himself in the face with force.

Case XIV.—J. A., an Irishman, aged 39. Dead three to four hours; heat 107° to 103°; neck very rigid; arms highly contractile.

Case XV.—J. G., a Baltimorean, aged 24. An hour after death, like the last; 108°.

Case XVI.—J. P., a Scotchman, aged 22. Dead one hour and a half; raised his fore-arm perpendicularly twice.

Case XVII.—R. C., a Kentuckian, aged 25. In two hours after death, when the arm was extended to an angle of 45° from the trunk, and was struck with my hand, or still better, with the side of the hatchet, carried his hand to his epigastrium; but when the arm was extended upon the floor, so as to form a right angle with the body, he slapped himself upon the mouth and nose. The contractility began to decline in the third hour, and by the fourth hour all motions of the limbs ceased, though the pectoral muscles assumed the ridgy or lumpy form when percussed. An hour after death the thigh was moderately contractile. The leg hung down near the floor; its flexors, after being struck, drew up the heel against the buttock. Heat for seven hours, from 111° to 102°. Five hours after death contractility ceased, and rigidity prevailed.

Case XVIII.—J. H., a Virginian, aged 30. Bled enormously, and cupped much; dead a few minutes; had contractility less than a quarter of an hour; dragged a hatchet along the floor, not being able to raise it. The heat, which was usually low, continued as long as observed, that is one hour and a quarter, without varying materially, not exceeding 102½°.

Case XIX.—N. E., an Italian, aged 25. Dead about one hour; heat 107° to 106°; recti muscles had contracted into indurated masses like knots of wood; neck rigid; the arm raised a weight, say 2 to 3lbs. fastened in the palm, carrying the hand to the umbilicus several times.

Case XX.—*Remittent.*—Mr. S., aged 45. Dead two hours; legs becoming rigid; struck the flexors of the arm with the inferior edge of my hand; the cadaver raised his arm with a regular, slow movement, placing his hand upon his breast: as soon as the muscles relaxed, he carried his arm back, extending the same. The experiment was repeated three or four times, when the arm fell back exhausted. The blows were now made with a piece of wood. The biceps gathered up into a lump, at the place where the blow was given, but failed to move the fore-arm.

Without attempting to give all the details of post-mortem contractility, it may be necessary to enumerate a few of its leading features.

Béclard asserts that the most remarkable and best established fact in the muscular action is, the shortening of the muscle during contraction; that its swelling is caused by its shortening, each compensating the other mutually.—*Gen. Anat.*

It is natural to every muscle, says Haller, to shorten itself, by retracting its extremities towards its belly or middle; when in action, becoming shorter and thicker (cccci.). Whether this doctrine be true of galvanic muscular contraction, I do not know, but I am certain that it does not apply to post-mortem contraction,—because it often happens that both

the fore-arm and elbow-joint are stiff and immovable, while the biceps may be powerfully contractile, its belly swelling up into a hard lump; relaxing and contracting repeatedly, and unavailingly, owing to the rigidity at and below its insertion in the arm. Here, it is evident that the indurated swelling is not owing to the approximation of the two extremities of the muscle, for they are fixed. The increase of volume seems to be owing to an expansion with rigidity among its elementary fibres; a zigzag oscillatory motion upon the summits of the contracting masses is visible to the naked eye. Much evidence might be produced besides the following:

*Cases of Post-Mortem Muscular Contraction without shortening in yellow fever Subjects.*

Case XXI.—H. F., a German, aged 28. Dead four hours, and dissected. The fingers and toes flexed and rigid; the biceps and gastrocnemius contracted, but without causing motions, as the limbs were rigid at their extremities.

Case XXII.—R. P., an Irishman, aged 24. Dead ten hours; fore-arm rigid; the biceps contracted strongly, but the rigidity in and below the elbow-joint prevented flexion. Blows with the knuckles over the pectoral muscles caused them to heave up into knotty masses.

Sometimes, post-mortem *rigidity sets in during the paroxysm of contraction*, producing a very singular phenomenon, a hard mass, which, continuing for hours, feels like bone. I have known this to be mistaken for a fracture badly set, or for a bony tumor.

Case XXIII.—J. C., an Irishman, aged 26. From one to three hours after death, the arms performed complete flexions and extensions; heat from 109° to 102°; six hours after death, the arms could not be extended without cutting the muscles, which were indurated and elevated at the site of the blows, having assumed the same arrangement as at the maximum of contraction.

*Cases illustrative of the Increase, Declination, and subsequent Resuscitation of Post-Mortem Contractility; all being yellow fever except the last.*

Case XXIV.—From four to five hours after death, and two hours after dissection, and the removal of the entire viscera, the *cadaver* being warm and rigid, great force was found necessary to extend the arm to a right angle with the body—extensions, flexions, and frictions were used, after which, a blow caused the fore-arm to rise until the hand pointed to the zenith; the motion was slow and equable; a second blow caused a slight motion without elevating the arm.

Case XXV.—A. G. G., a New Yorker, aged 30. In a few minutes after death, presented but feeble contractions, which, in half an hour ceased for a time. But soon after the contractile function returned to the same arm with much force, but after repeated blows it was exhausted a second time. Again, after a similar interval, it returned with a like force a third time. In three hours the rigidity, beginning in the neck, extended itself to most parts of the *cadaver*. The blows were found to have caused well-marked contusions, cellular ecchymoses, &c.

Case XXVI.—C. L., an Irishman, aged 31. Was observed from five minutes to an hour after death; the contractility was found to be active, but after appending a weight of 2 to 3 lbs. to the hand, the arm

was unable to raise the weight more than twice ; a third blow caused the biceps to be convulsed ; it gathered up in a knotty heap, which, by forcible extensions and frictions, was, at length, removed temporarily, but in half an hour it returned, and was unchanged as long as observed, being to the touch like a bony tumor.

Case XXVII.—C. S., a German, aged 50. Observations from fifteen minutes to two hours after death ; heat from 109° to 102° ; the contractility, though strong, was extinguished in the right arm by five or six blows. The left arm, about two hours after, was somewhat rigid, but frictions and extensions caused the contractile function to revive again.

*Fracture of the Leg—Gangrene—Death.*

Case XXVIII.—J. A., a German, aged 33. Dead two and a half hours ; winter, room 54½° ; a single blow with the flat side of the hatchet produced flexion, but exhausted the contractile force for half an hour, when it slightly returned. The supinators and pronators acted for an hour longer than the flexors of the arm ; the experiments ending five hours after death.

*The Destruction of the Contractile Function in one arm does not affect the other ; this rule has no exceptions, and is illustrated in the following Yellow Fever Cadaver :*

Case XXIX.—S. F., a Cincinnatian, aged 24. Dead half an hour when the experiments began. The right arm was struck with the flat side of the hatchet, the hand was carried to the ear ; the second time to the mammary region ; a third to the perpendicular ; a fourth caused but a slight motion, and two more, more severely laid on, completely killed the contractility, leaving the print of the instrument as upon dough. In an hour after, the left arm was found to be contractile as the right had been, if not more so. The thigh, two hours after death, and an hour after the removal of the viscera, gave nearly 107. Other cases illustrative of this point are deemed superfluous.

*If several blows on the same spot follow each other rapidly, there is but one contraction, but they exhaust the contractile function more than a single blow ; if the force be greatly augmented, the contractility may be killed, almost immediately, in the muscle struck, without impairing the action of any other part.*

This force has no resemblance to that purely physical property of bodies, called elasticity. A man may stand on the hand of the cadaver while the blow is being made on the biceps ; let him then step off the hand, and the contraction will follow as usual. If the power be feeble, the relaxation will be quick in most cases ; the arm will fall back upon the plane from all points short of the perpendicular, each elevation being less than the preceding one, until the force is expended. Should the hand pass its meridian, gravitation will of course aid the contraction in bringing it to the trunk.

The blood has no appreciable influence upon post-mortem contractility, because when the limb is severed from the trunk and drained of its blood, its action is not thereby diminished. Hence the following statement by Sir Charles Bell in his work on the hand requires, at least in the dead subject, some modification :—

"The muscular tissue has a living endowment, a power of contraction and relaxation, which is supplied by the circulation of the blood, the source of all vital power."

In some instances, as in the following, great losses of blood before death were not preventive of the most intense post-mortem contractions.

*Much Ante-mortem Hemorrhage, moderate Post-mortem Caloricity, with powerful Contractions :—*

Case XXX.—M. D., a female, aged 30. Dead half an hour; had an enormous sub-mammary effusion of blood, forming a bed two feet in circumference, amounting to several pounds; the fore-arm was raised, and the hand brought to the umbilical region after each blow; in three hours slight rigidity was noticed in the neck; in five hours, when burial took place, every joint not included in the neck, was perfectly flexible. The axilla and vagina did not range above 100°.

The difficulty, perhaps I should say impossibility, of showing any exact and necessary connexions between cadaveric contraction, flexibility, and temperature, will be best illustrated by giving an outline of a few cases. It will be seen that contractility may be present where the heat is, at least, very moderate, and where it is greatest for seven hours after death, that rigidity may take place much in advance of the maximum heat. Rigidity is at first local, often irregular, and sometimes absent as long as looked for, and may possibly never take place, as I might more fully show were it necessary. Contractility may take place during the rise or fall of the temperature, indifferently and in one region, while rigidity may prevail in another, and is sometimes absent in cases where great heat and flexibility are present.

*The following are Cases illustrative of Contractility in connection with Post-mortem Calorification and Partial Rigidity; the maximum and minimum temperatures being included :—*

Case XXXI.—J. K., a Philadelphian, aged 25. In fifteen minutes after death presented the contractile phenomena in its most intense form, but which declined wholly in one hour, the body being everywhere flexible. In half an hour after rigidity set in. This body, which before death had been remarkably cold, had a temperature after death as high as 109°, and which did not refrigerate below 104° in three hours after.

Case XXXII.—L. S., a Swede, aged 48. In three hours after death was rigid in his legs, neck and jaws. The arms had lost nearly all contractility, while the axilla and perineum, each, gave 109°; at five and a half hours the heat was still 103°, long after rigidity had become general.

Case XXXIII.—J. H., an Irishman, aged 36. Of gigantic frame, estimated at 200 lbs.; in fifteen minutes after death the neck, jaws, and recti muscles were immovably fixed—the contractility of the arm being very powerful. In an hour and ten minutes the rigidity became universal, the thigh being at 107°. In one and a half hours the epigastrium was at 106½°, and the brain 101°.

Case XXXIV.—S. G., a New Yorker, aged 22. In fifteen minutes after death, presented contractility in its most active form; the entire

body being flexible, but soon after the neck became stiff, then the legs, arms, &c. The temperature in the axilla and thigh exceeded 107° ; in an hour and a half it was nearly the same: in three hours the thigh was 100°.

Case XXXV.—J. Q., a German, aged 24. In three fourths of an hour after death was universally flexible, and contractility was powerful, temperature 109° ; in an hour rigidity took place. In two and a half hours the heat was nearly 107°.

*Cases without contractility, showing the temperature to be high with or without flexibility.*

Case XXXVI.—J. S., a German, aged 29. One hour after death, rigid in the neck and legs, moderately so in the arms ; axilla, chest and epigastrium, each 107°, thigh 104° ; in about four hours universal rigidity, thigh 105°.

Case XXXVII.—C. B., a New Yorker, aged 23. In one hour after death, neck rigid, legs and arms moderately so ; universal rigidity in two hours ; the thigh did not reach its maximum, 104°, until sixteen minutes after.

Case XXXVIII.—M. H., a German, aged 32. In about fifteen minutes after death was everywhere flexible ; in half an hour the limbs, which were without contractility, became stiff, the thigh being nearly 107° ; two hours later the latter was 106°.

Case XXXIX.—G. L., a German. At two hours after death had flexibility of the neck and rigidity of the limbs and recti muscles, with a heat of 104° ; in four hours the body, excepting the neck, was very rigid, the heat being only one degree less in the centre.

Case XL.—J. F., a female. In two hours after death was extremely rigid in the superior extremities ; the neck, legs, &c., being limber ; the heat being 104°, and in an hour after 105° ; at three and a half hours, neck limber, legs, &c., stiff ; heat 104°, and at the fifth hour 102½° ; at the seventh hour the thigh was 100°, the body rigid, and the neck still perfectly limber and as at first.

The continuance of, or rather the degree in which post-mortem heat is evolved bears no proportion, I repeat, to the intensity of post-mortem contraction. The great heat developed in the dead body, I have endeavored to illustrate in the medical journals of our country, and will not, therefore, dwell upon that subject at present. I find, however, on examination of the original papers not yet published in detail, that for the most part, when the heat had declined, the contractility was exhausted, but that the presence of great heat, ranging as high as 113°, did not by any means imply the presence of contractility, nor the absence of rigidity. Authors seem not to have been aware of the augmentation of animal heat after death ; some have, it is true, noticed an increase of heat after death from cholera, compared with the extreme coldness of the surface during the last hours of life : but has any one hinted that this post-mortem heat ever rose as high as even the healthy standard, to say nothing of 14° or 15° beyond that ? I mention this merely to explain what MM. Orfila and Nysten mean by *animal heat*, when they assert "that rigidity is incompatible with its presence."—(*Todd's Cyc. Anat. & Phys.*) Dr. Beatty advances the same doctrine (*Cyc. Prac. Med.*) ; so does Béclard (*Gen. Anat.*), not to name many

others. Nothing can be more erroneous. The heat often increases with the rigidity.

*Post-mortem contractility, in the human cadaver, has no connection with or dependence upon, the spinal marrow. This may be received as an axiom, though directly opposed to the reflex theory, and is easily proved by amputating the shoulder in a proper manner.** In performing this operation, it is best to leave a few portions of the skin undivided, so as to tie the arm down to the trunk, so that the former during action may not turn quite over. I select the following yellow fever cases for illustration.

Case XLI.—A. M., a German, aged 30. More than four hours after death, and one hour after dissection, possessed the contractile function in a high degree. An arm was amputated so as to include the scapula and its muscles; after which, blows were repeatedly directed upon the flexors of the fore-arm, which was as often elevated to the perpendicular; one of the inferior extremities, an hour after amputation at the hip-joint, being generally rigid, presented, nevertheless, contractility in the form of massive ridges at the places of contact from blows.

Case XLII.—P. L., an Irishman, aged 20. Dead four hours before the experiments were begun. Both fore-arms raised themselves to the perpendicular several times. The left arm was amputated so as to include the scapula and its muscles. Twenty ounces of blood by estimation were rapidly discharged by the operation. The temperature had ranged for more than four hours in different regions, at from 34° to 33° of Réaumur (nearly 109° to 106½° of Fah.). The arm was more contractile after than before its separation from the spinal marrow, rising after each blow without any loss of motor force as long as observed.

*Cases showing that Amputation of the Shoulder, and the subsequent Division of all the Nerves, Vessels and Muscles of the Arm, except the perpendicular Flexors of the Fore-arm, do not in the least impair the contractile function either in force or duration:—*

Case XLIII.—J. G., an Irishman, aged 32. Dead three hours; dissected one hour; viscera all removed from the body; the right arm was extended, and slapped with a piece of shingle, the force being scarcely sufficient to injure a living person. This blow was repeated at intervals five or six times; each time the man struck his hand against his shoulder with great celerity and force. A heavy hammer was then tied in the palm of the hand, but even this failed to counteract the muscular force; he struck himself heavily against the breast. A hatchet estimated at 2½ to 3 lbs., was substituted for the hammer; with this he struck the breast several times, when the contractility suddenly ceased. One hour after this, and more than four after death, both arms, including the scapulary muscles, were amputated, discharging enormous quantities of

* We have Bentham's authority, "that no man doth wrong for wrong's sake;" but still, it would seem, that some will argue for argument's sake. It has been said that the biceps, after cutting off the shoulder, and all the accessible nerves of the arm, and all the muscles not devoted to flexion, *still has nerves* blended with its texture. Hence its contractility! Now, at the least, this separation from the spinal marrow and division of all the nerves, ought to lessen in a corresponding ratio the force and duration of the contractile function. Yet this never happens. The nervous connexions and influences reduced to zero, leave the muscular force at its maximum. Defeated in the spinal reflex action, these men substitute some invisible nerve! Drowning men catch at straws. Alas! for reflex logic!

blood—hot blood—for the post-mortem temperature had been ranging from 36° to 34° of Réaumur (or 113° to 109° of Fah.); the left arm was extended on the table, resting on the hand and on the olecranon, on the angle of the scapula and the sternal end of the clavicle, presenting the deltoid uppermost. The most active contractions followed every blow, the arm twisted about like a wounded snake, the muscles of the scapula were convulsed. The shoulder having lost its *point d'appui* upon the trunk, the whole arm sometimes turned over, so that the deltoid rested on the table. Gradually, as in the former case, the contractility began to decline. I now severed all the muscles of the arm, in its lower third, except the biceps and brachiales, including all the accessible nerves and vessels, but I found the contractility as active as before. It was, of course, moderate from the previous exhaustion. The amputation at the shoulder, the cutting of all muscles, &c., but the flexors, had not impaired the contractile function in the least. The amputated limbs remained very warm about three hours.

According to Bichât, the more rapid the death, the more powerful and enduring are the contractions caused by galvanism. This rule has no certain application to yellow fever subjects, in whom percussion produces the greatest muscular activity. Still, however, it must be admitted, as a general rule, that yellow fever, which is so rapid in its march, presents more frequent and enduring cases of contractility than other fevers, according to my experience. But when we come to particularise individual *cadavera* in yellow fever, it will be found very often, that among those who have died most quickly, contractility will be present, or absent, just as among those who had lingered for a longer period.* Judging from the published accounts of galvanic muscular action in criminals after execution, I suppose that the yellow fever subject often presents a greater susceptibility to contraction. Professor Guy "*limits the contractile period in extreme cases to two hours.*"—(*Med. Juris.*)—Professor Dunglison "*to two hours after the cessation of respiration.*"—*Phys.*, vol. i., p. 338.) Percussion, as I have often observed, excites contractions in the yellow fever subject many hours—one to fourteen—after death, and even hours after complete dissection of the brain, spinal cord, viscera, and limbs, and the removal of many pounds of blood, as the case above mentioned will show.

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* The contractile force is to the organic muscular system, what gravitation is to the inorganic kingdom. The one is intermitting; the other unceasing: both are ultimate, and therefore inexplicable principles.

The explanation of muscular action by the anterior roots of the spinal cord, though it meets the eye from every point of the medical horizon, is, I repeat it, wholly unsatisfactory. The same may be said of the pathological facts which are relied on to prove the reflex doctrine. Not to repeat what I have elsewhere said, I will quote *Béclard*, who, after declaring the spinal cord to have but one office, namely, that of a conductor transmitting a sensation by its posterior, and motion by its anterior roots,—being the seat of the principle of irritability, so that its destruction or removal renders the excitation of motions impossible, adds, that he has made many experiments upon animals, showing that injury of the nerves is followed by no grave accidents—the reunion and the re-establishment functions take place very promptly. (*Gen. Anat., passim.*) The practical Sir Astley Cooper, after many *bonâ fide* operations upon the *human nerves* for tumors and the like, having twice removed portions of the great sciatic nerve, concludes, that "wounds of the nerves are followed by little irritation—that they are very rarely inflamed, and that tetanus is the result of injury to tendinous rather than to nervous structures." (*Lect., Tyrrel's Edit.*, vol. i., p. 245; vol. iii., p. 125.)

Mr. John Felix, a young gentleman of veracity, long a resident student in the Charity Hospital, has just informed me that a man who died of a thoracic affection on the 3d of Jan., 1846, fourteen hours after death presented a strong example of muscular contraction, the fore-arm having been elevated to the perpendicular after each blow given with the inferior edge of the operator's hand. I may be allowed to remark, that the professor of physiology should consider his course incomplete without demonstrating the phenomena of muscular action, thus laid bare to the view of his class—a process so slow, so lucid, and so unlike the muscular convulsions excited by galvanic piles, wires, nerves, and the like, as to produce on the minds of the beholder an indelible impression. Here seeing is believing. The explanation, as in all ultimate facts or laws, may be impossible, as in gravitation, attraction, and so forth. This, however, is no valid objection. When a vivisector gives his experiments, we cannot verify them without trailing with him through the blood of animals half dead or killed for the purpose—a method too repulsive to be practised—which cannot be said of percussion, since it does not require a wound even in the *cadaver*. Mr. Brereton, who, by the way, is not, and, I believe, never was a worshipper of the Reflex Idol, says "that according to his experience the reflex action is never developed when *sensation is completely destroyed*."—(*Lancet*, 1844.) The bare possibility of this is a fatal objection.

Post-mortem Contractility, when excited by percussion, is the best fundamental type of the periodicity of the contractile function,—better, certainly, than that originating in galvanic electricity; voluntary action may be much more perfect; electric action necessarily more rapid. The contraction operates for several seconds or minutes. Relaxation, by which the muscle is made to assume its normal figure, presents another distinct interval. The counter-motion, though less prolonged, is equally distinct. Then comes the period of repose (analogous to that following the fatigue, in living muscles), the forerunner of renewed efforts—efforts, however, which must speedily exhaust the quantum of contractile force for ever. The period of exhaustion may be hastened or deferred, in many cases, according to the manner of procedure. The contractility may be *killed* by a severe blow, especially if at the same time a weight be fastened in the palm. It is worthy of remark, that by a proper application of blows, all the elemental motions of the arm may be produced more or less perfectly, as flexion, etc.

Does percussion act in any sense like galvanic electricity? Let us see. Is the cuticle any barrier to percussion? No. Does percussion require a complete circle of metals, nerves, and muscles? No. Does it act through the anterior roots, or other portion of the spinal cord? No. Does it act in a rapid, inconceivably rapid, convulsive manner? No. Dr. Hooper says, in speaking of galvanic action in frogs, &c., that "contractions can be excited even to the instant of incipient putrefaction," and, if so, here is another great difference. Motion, by this method, is diametrically opposed to every kind of motion known in natural philosophy: it is opposed to the Newtonian law of mechanics, which requires motion to be in a straight line—to be in proportion to the impressing force, and, in the opposite direction, to be equal and contrary to the re-action. A more complete contrast to these laws cannot be imagined, than that a blow, the direction of which is towards the side of the arm opposite the biceps, should cause a contrary motion to that of flexion,

to say nothing of a slow intermediate motion incidental to the relaxation of large dense masses of muscle, and, lastly, extension—a counter motion. If we could explain mechanically, that movement which causes the *cadaver* to lay his hand on his breast, where, by the great law of *inertia*, it ought for ever to remain, we must fail to explain the contrary motion, by the same force: dead matter, once at rest, cannot pass into a state of motion by any inherent power of its own. We are, therefore, obliged to admit the existence of a force—a force adequate, not only to overcome the *inertia* of the arm itself, but that of weights placed in the palm: to call this principle chemical, electrical, reflex, or mechanical, is chimerical. If we reject a vital force, in this case, some name, however unmeaning, may be substituted: call it the *vis musculosa*, or the *Essence of Owl*, as the East Indians denominate the agent which causes epidemics (as we are told by Bishop Heber). It is a force totally unlike that from impulsion, since it bears no relation to the momentum, direction, or instantaneousness of the impinging body. It is, as already mentioned, unlike electricity, which would probably travel round the globe thirty times during the period necessary to produce one contraction of the biceps. It is unlike mechanical, chemical, cohesive, and gravitative forces, being *sui generis*. Here we must adopt the last words uttered by the astronomer, La Place, "*Ce que nous connuissons est peu de chose, ce que nous ignorons est immense.*" "We should wander on eternally in darkness," says Bichât, "the moment we quit the plain path of experiment. Let us be contented, therefore, to collect facts, examine and compare them together, and make ourselves acquainted with their general results. Such inquiries can form the only true theory of the vital powers; all beyond it is conjecture."—(*Res. on Life and Death.*) To attempt an explanation of this phenomenon by means of a cataract of such words as reflex, efferent, afferent, chemical, galvanic, is idle. Whenever muscular contraction shall be ascertained to be a simple element, or a compound, having a definite chemical character, then it will deserve a suitable chemical name; until then, an unmeaning, or non-theoretical name, is as good as any; indeed, the *vis vitæ*, is very much of that sort; for, strictly speaking, it represents a mass of facts, not yet rendered amenable to the laws of the physical sciences, rising, as it does, above or beyond inert matter, and being very often opposed to the *modus operandi* of the latter, so far as our present knowledge goes.

The unbelievers in the *vis vitæ*, though often regarded as a sort of atheists in physiology, are, notwithstanding their materialism, no unbelievers at all, except when *vitalism* is concerned. They are sufficiently credulous, in advance of experimental proof, to believe, that life is only so much electricity, or galvanism, or magnetism, or chemical, crystallized matter. Even some of the vitalists themselves hold that life is matter of an imponderable and sublimated character.

Were I to assert, that the *vis percussionis*, by exciting the *vis musculosa* or the *vis motoria*, overcomes the *vis inertiæ*, and at the same time maintain that these words afforded an explanation of the phenomena in question, nothing would appear more ridiculous. But, when these terms are used simply to characterize three different classes of facts, often conjoined in a manner wholly unknown, yet so linked together that one follows the other in a definite order, then the case is quite different. The *vis inertiæ*, though apparently the simplest law of matter, is, in truth, like

motion by contact, one of the greatest stumbling-blocks in philosophy, to say nothing of the more obscure and eccentric laws of vitalism.

The *vis vitæ* and the *vis inertiæ*, or the animal and mechanical laws, perpetually intersect, retard, accelerate, modify or combine with each other. The former, extremely complex, and marked by intermitting actions, with intervals of repose, is always more or less amenable to the laws of inert matter. In the present instance, the flexors of the arm, inserted as they are in the unfavorable end of a long lever, near the fulcrum or elbow joint, must be considered as exerting a great force to raise the arm alone, to say nothing of weights placed in the palm. The raising of three pounds, placed in the extreme end of the lever or palm, according to the *data* of physiologists, is nearly equal to 200 lbs.! In some instances, I suppose the weights raised might have been more than doubled without counterbalancing the contractile force. Thus, by adding the weight of the arm or lever beyond the insertion of the biceps, the whole will amount to about 10 or 12 lbs., having an enormous leverage, like a pair of steelyards. Be the muscular force what it may, it contends face to face with the *vis inertiæ*, which it antagonizes for a certain period in the *cadaver*, independently of the galvanic circle of metals, muscles and nerves, and in opposition to the reflex logic. Why employ a complicated apparatus, when a stroke with the hand, a horn,* a cane, or hatchet, will answer better? "Every muscle," says Bichât, "which has been strongly contracted, requires a certain period of relaxation, before it can be excited again by contraction. Hence the necessary intermissions of locomotion and voice."

The contractile function in the *cadaver* presents several phenomena already alluded to, more curious and difficult to explain than simple contraction, as, relaxation and counter-action. "The contraction of the muscle," says Professor Dunglison, "is followed by its *relaxation;* the fibres returning to their former parallel condition. This appears to be a *passive state*, and to result from the suppression of the nervous influx by the will; in other words, to be produced by the simple cessation of contraction. Some have, however, regarded both states to be active, but without proof. Barthez maintains, that "the relaxation of the muscle is produced by a nervous action, the reverse of that which occasions its contraction; the will relaxing the muscles as well as contracting them." This latter view, omitting the supposed agencies of the nerves and the will, receives support from cadaveric phenomena. The contractile force elevates the fore-arm, with or without a weight in the palm, so as to rest against the breast. The *vis inertiæ* requires these masses to remain at rest. This sometimes actually happens, after one or more contractions. If the last blow has completely exhausted the motor power, the muscle does not relax in some few cases. The tumefied, dense zigzag mass remains contracted until the *rigor mortis* supervenes.† But, in other cases, this relaxation is repeated, as if by inter-

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* I have, for reasons that will occur to the reader, used both conductors and non-conductors of electricity, in exciting contraction, and have caused the hand of the *cadaver* to be held down, that the mere mechanical impulse of the blow might first pass off,—a useless precaution, which I was driven to by some theorists, who, not admitting anything to be new under the sun, vainly puzzled themselves with fanciful explanations.

† This occurrence affords, as I imagine, the very best opportunity for the student of minute and microscopic anatomy, to ascertain the structural phenomena inciden-

mediate power, the forerunner of a powerful counter-action, or extension of the arm. These antagonistic and intermediary movements seem to indicate a three-fold power. In the living body frictions cause the speedy relaxation of those painful, knotty masses of muscle, called cramps; sometimes in the dead body, the period of the contraction of the muscle may be shortened, and that of relaxation hastened by the same means. Even after the *rigor mortis* has declared itself, the arms, by flexions, extensions, and frictions, may sometimes be restored to a contractile condition, as already shown.

Upon the whole, the percussional method, how simple soever it may seem, gives rise to very interesting phenomena, of a character but little complex, and though it may lack the dignity of galvanic machinery, the horrors of vivisections, and the mystery of the reflex theory, yet it should not be ridiculed, nor condemned, because it fails in dramatic effect.

The illustrious Franklin had published his hypothesis, namely, *that lightning and electricity were the same*, before he had positive evidence of its truth. But when he undertook the experimental proof, by means of a kite, made of a silk handkerchief, such was his dread of being laughed at by the Philadelphians for the simplicity of his proceeding, that he let no one but his son know it. He went to a retired place in a shed, and sent up his kite. A cloud passed, but without effect. He was in despair. Another cloud arose. He now drew down the lightning. Hypothesis became fact. Franklin had the sublime pleasure, perhaps never before equalled, of subjecting the dread thunderbolts of Heaven to his will. The kite experiment gave place to millions of lightning rods, which everywhere bristle against the skies to disarm the thunder-bearing cloud of its terrors, and to perpetuate the name of the experimenter. Gratitude, not ridicule, was his reward. This statement, though a digression, serves to show that the most simple experiment may lead to the most important results.

Bichât's doctrine of two lives—one, the perceiving, feeling, willing, moving, external, called the animal; the other, the nutritive, the negative, internal, called the organic; may serve to illustrate post-mortem contraction. Without admitting to the fullest extent, with Bichât and Broussais, that contractility is a "fundamental, vital property," we might justly regard it as a leading feature in the vital phenomena of at least one tissue,—the muscular. If we regard life, not as a unity, nor yet as a duality, but as a multiform aggregation of particular vitalities, the harmonious operation of which constitutes health, the derangement of which constitutes disease, and the general dissolution of which constitutes death, then it will not be unreasonable to suppose, that each tissue, having a kind of sub-life, or special life of its own, may die before, or after some other tissues. Hence, the muscular and capillary tissues may, and often do, survive death in this detailed sense, among the numerous structures and functions of the general system. But the presence of

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tal to the contracted state of the muscular tissue, as the *rigor mortis* in this fixes, as if by congelation, or petrifaction, all the parts, exactly at the moment of their contraction. Certain it is, that an apparent increased cohesion, and augmentation of volume, may take place without any approximation of the ends of the muscle, as when the fore-arm is rigid; while the belly of the biceps is strongly contractile, though both its ends may be fixed as already explained.

this muscular life, isolated from all other vital phenomena, furnishes no positive proof of the presence of what is strictly and popularly called life.

After the death of the brain, the lungs, the heart, the senses, the will, &c., a degree of vitality in its simplest elementary form seems to linger in the muscular tissues, and which impulsion makes manifest by a route so direct and short, that the motor power and the contractile phenomena appear absolutely conjoined as cause and effect; and if its *modus* is not easily understood, neither does it assume a host of inexplicable agents—nor afferent, nor efferent roads, as in the reflex system. It does not offer an assumed, circuitous transmission as a good explanation.

Post-mortem contractility being, as we have seen, independent of the nervous system, suggests many important physiological and pathological truths to the impartial inquirer. Probably many of those diseases now attributed solely to lesions of innervation,* begin, continue, and end chiefly in the muscular system; for example, tetanus, spasms of the gullet, stomach, bowels, bladder, urethra, womb, and hour-glass-contraction, cramps, &c. Why resort to a lesion of innervation—a lesion not discoverable before or after death, by any of our senses, when the patient and his attendant have every proof of a muscular disease, in tetanus, for example? Haller mentions a girl affected with tetanus, bent backward (opisthotonos), whose abdomen sustained a weight of 800 lbs., without straightening the body! Simple rigidity, so universal and persistent, is quite sufficient to exhaust and to kill, as every one at all acquainted with the essentially remitting action of the muscular system in health must know. Let the morbid anatomist not direct his whole attention to the brain and nerves, in these cases; it may seem more learned to dwell on assumed functions of the spinal, ganglionic, and central nerves, and their reflex action, &c. The muscles should be examined—their color, cohesion, texture, &c. Does the tetanic rigidity relax to be replaced by cadaveric rigidity, &c.? Might not the subcutaneous operation of dividing one of the tendinous ends of a wounded muscle, as soon as the first symptom of tetanus declared itself, prevent

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* *Innervation!* Happy word to conceal our ignorance! It merits all the benedictions which Sancho Panza pronounced upon the inventor of sleep, "it covers us over like a garment!"

"*Innervation*," says Professor Harrison of New Orleans, "includes five classes of phenomena—*change of nutritive action, muscular motion, sensation, the intellectual affections, and the emotions;* but as the change is essentially chemical, it is obvious that in each of the latter the first is included. Muscular action, sensation, thought, &c., are, therefore, mere results, &c."—(*Nerv. Sys.*, p. 64.)

The spinal cord seems to be the grand laboratory of Innervation. The spinal chemistry, the spinal physiology, and the spinal pathology, are sufficiently mysterious in themselves; but when enveloped in the dense fogs of the reflex action, ebbing and flowing, no one can tell which way the land lies—a stratum of fog rolls along the sky, shutting out the light—another still darker scuds along the land and the water, hiding both; it is a poor consolation to hear that one mass is afferent, and the other efferent.

Though a little out of place, I will take the liberty of making another quotation from my learned *confrère*, who has so ably advocated the cause of the Chemical School. "Every case of fever from a local injury is but a manifestation of reflex action from the spinal cord. All the tissues are affected by the reflex action of the spinal cord;—these are chemical changes, because the essential actions of life are themselves of a chemical character."—(Pp. 24, 55.)

the development of that horrible disease? When cramps, convulsions, and spasms, present themselves in the muscles with evident changes, even before death, why should we invoke the nerves, exclusively, in which changes cannot be demonstrated? The spinal marrow is, doubtlessly, necessary to health, and liable to disease,* but these are muscles by no means over-rich in nerves that are quite as necessary to life. The heart will bear vivisection still less than the brain and spinal cord. To expound pathology chiefly by supposing changes in the nervous tissue that cannot be recognized by our senses, neither before nor after death, or to rely on equivocal vivisections, as the cutting up of all the other tissues, or opening the brain to get at the great nerves of the centre, is truly a reflex, not a direct road to the knowledge of the theory and practice of medicine. And when Dr. M. Hall positively asserts that "the *whole tone* of the muscular system," and "*all* spasmodic diseases, belong to the reflex function of the spinal cord," we must dissent with all due deference to an authority so highly respectable. That the muscles may be primarily affected by many diseases is by no means improbable. In the commencement of fever, especially of yellow fever, the patient more uniformly complains of soreness and pricking pains in the muscular parts than of the head, or spinal marrow. To feel "tired all over" (to use the patient's usual phrase) is more characteristic than even chills. At all events, the pathology of the nervous system is not, as yet, sufficiently certain to justify us in ascribing such symptoms exclusively to the ganglionic, central, or spinal nerves.

Let us return a moment to tetanus,—the type of reflex pathology; the disease, above all others, wherein no morbid change is met with in the nervous system, its supposed seat, according to all the great authorities, as Larrey, Cooper, Hennen, and others. Curling, in his prize essay, says the same; yet he ascribes the disease to the motory tract (*tractus motorius*). Larrey refers this disease to the spinal cord, though his facts, and even his method of cure, have, if I may judge, a contrary import. Does not his method of amputation, in the incipient stage, cure by relaxing the muscular tension of the limb, rather than that of the anterior roots? Dr. Hennen, in his dissections, looked, where others have looked, into the viscera and nervous system, only to be disappointed; and yet he incidentally mentions having found "*the muscles a good deal injected with a serous effusion.*"

Mr. Curling, in his prize essay on tetanus, remarks: "*The muscles are not usually rigid after death.*" Dupuytren somewhere mentions that he found the muscles after death from tetanus reddened and engorged. In his "Clinical Surgery" (chapter xvi.), I find the following passage:—"*Necropsy of J. B. Roger* (who had died of tetanus), *thirty-six hours after death. Great rigidity of all the parts of the body which had not been affected with tetanus;* but the muscles of the neck, shoulders, and, in general, all those regions in which the tetanic rigidity had existed, *were completely relaxed.*"

Now, instead of going upon a circuitous route to the anterior roots for an explanation of either relaxation or rigidity, it would be easier to look

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* A voluminous French author, the late M. Pinel, never saw but three cases of softening of the spinal marrow, two of which were published by M. Magendie, in his Journal, in 1821.—(*Med. Times, Sept.*, 1845.)

to the muscles themselves. Is not the *rigor mortis* the last struggle of the expiring muscles? When their force has been nearly *exhausted*, perhaps completely *killed*, by the morbid or tetanic rigidity, is it not reasonable to suppose that the *rigor mortis* would be greatly modified in degree or duration, if not prevented altogether? Do not the tetanized muscles putrefy in advance of the non-tetanized? Every dissector sees, in the relaxation or flexibility which follows cadaverous stiffness, the first step towards putrefaction; and where the former does not appear at all, or is very transient, the latter supervenes with the greatest rapidity. (It is right that I state I have never made *post-mortem* examination in this malady with care.)

In connection with this topic, I may be allowed to merely glance at a curious fact, the full development of which requires a distinct monograph, in the morbid anatomy of southern fevers, be the subjects thereof from the tropics, the temperate, or the frigid zones, showing that the intestinal canal, chiefly from the ileo-cœcal valve to the anus, is often contracted into a round, consolidated cord, without having any of those changes designated by atrophy, hypertrophy, hyperæmia, or inflammation. This contraction, for reasons which I cannot now offer, must exist anterior to death, and continues (during the general *post-mortem* rigidity and relaxation of the *cadaver*) up to the putrefactive period, obliterating the intestinal cavity. If any fæces be present, they are strongly compressed either into rods or balls, being nearly dry. Sometimes the large intestine resembles a cord with knots, at intervals, owing to scybalæ, and seems, moreover, considerably shortened. In other cases, and indeed very often, the natural notchings, puckerings, and pouches, are replaced by smooth surfaces, the whole intestine not exceeding the thumb in size. In rare instances, the contractions take place at intervals, leaving intervening links of the natural dimensions. These contractions strongly oppose attempts at dilatation. Is this lesion tetanus of the intestinal muscular tissue or coat?

In the *Gazette Médicale*, of February, 1845, Dr. L. A. Mercier relates that M. Amussat, having introduced a small bougie into the urethra, found it equally impossible to pass it into the bladder, or to withdraw it, until he had forced an injection into the canal. Dupuytren says: "The first touch of the bougie causes the canal to contract, so that it is disengaged with difficulty." Now, this contraction appears to me direct, not reflex, being excited in the urethra and in its contiguous muscles by disease, pressure, &c., not wholly unlike post-mortem contraction from a blow.

In cases of retention of urine, wherein the usual means fail, success may be expected, generally, by prolonged pressure with the catheter exciting violent muscular contraction, which, like healthy and post-mortem action, has a tendency to exhaust itself, or pass into relaxation, agreeably to one of its great laws, periodicity, and thus allowing the instrument to pass. Hernia, dislocations, and the like, might also be referred to in illustration.

A great many involuntary tonic and clonic contractions seem to be far more muscular than reflex and nervous in their origin and progress, being, in their irregular or morbid character, more or less subject to the great physiological law of intermittence, which is most clearly developed in the *cadaver*. It is a far-fetched explanation of parturition, to refer it to the reflex action of the spinal cord! The pains in expelling the child,

the placenta, coagula, &c., usually lasting several days, are just such as might be expected in a great hollow muscle while contracting, though in these, as in all cases, there is doubtless a participation of the nervous and other tissues.

Simple contraction of the muscular tissue of the uterus is quite sufficient to account for the principal phenomena, without reflex action.

*Cramps*, in cholera, yellow fever, etc., are, no doubt, what they seem to be, affections of the muscles, not of the anterior roots of the spinal nerves. There is a possibility of being too profound for either physic or philosophy; cramps, morbid changes, inflammations, and the like, are disdainfully called nothing but effects—and truly they are of that character among the all-knowing immortals—as much so, without doubt, as gravitation, which is also an effect, though, to all mortal men, it must be regarded, for practical purposes, as a cause or ultimate principle, beyond which we cannot go. How will such logicians explain the following two cases, upon which I found this question ?—

*Does muscular contraction, after death, ever show itself unconnected with any appreciable cause or excitant ?*

A young lady, who had been my patient, died of cholera, in 1833, at Wheeling, Virginia, during my visit to that town. I obtained, with difficulty, permission to make a *post-mortem* examination, at about three hours after death, when I found a brisk twitching of the fingers, somewhat like *subsultus tendinum*, being chiefly in the flexor muscles, which latter had suffered before death from cramps and strong flexions. Here the disease of the muscle, so to speak, was still operating !

The next case, still more remarkable, was most carefully noted at the instant of its occurrence, as follows:—1843, October 8th, 11 A.M. Peter Duffy, Irishman, aged 28, last from St. Louis, resident in New Orleans one month; sick four days; hand, 23° ; bend of the arm, 26° ; axilla, 28° of Réaumur; body curved to the right; fists clenched; forearms flexed, pressing against the chest; insensible; a column of black vomit, about twenty ounces, was projected from the mouth, like a *jet d'eau*, two or three feet perpendicularly : it fell back into the mouth, and on the right side of the face; the mouth being closed, two smaller streams were forcibly discharged through the nostrils upon the breast; the jaws became fixed; the lips compressed; respiration ceased. He was dead. Every part of his body was quiescent and motionless; but, soon after, he performed the following motions, occupying, by estimation, from three to five minutes:—First he carried his left hand, by a regular motion, to his throat, then to the crown of his head; the right arm followed the same route on the right side; the left hand was then carried back to the throat; thence to the breast, reversing all its original motions; the right hand and arm performed exactly the same motions: in all, eight consecutive, identical, equable motions, in apparently equal times, and with a regularity indicative of volition, though before death he was totally insensible.

Post-mortem contractility, in its legal applications, is not without interest, showing, as it does, the absurdity of some grave *judicial decisions*, based solely on muscular motion, which latter has been held to be a sufficient proof of life in a new-born child, enabling the husband to inherit the estate of his wife during his lifetime. In a case given

by Dr. Dunglison (*Phys.*, v. i.), the Court of Exchequer (in England) and the jury decided that the child was born alive, because, when it was immersed in a warm bath, a *twitching* and *tremulous motion* of the lips appeared twice. What would the Cokes and Blackstones of the law say, agreeably to this principle, on seeing a dissected, eviscerated man performing regular flexions, extensions, pronations, supinations,—lifting heavy weights from the floor and placing them on his chest? To designate the precise moment when living becomes dead matter is indeed a desideratum: "to be, or not to be, that is the question" which science, humanity, and the strongest of the human passions have not been able to solve.

Although three centuries have rolled away, no anatomist, no medical man, can think of the melancholy fate of the illustrious "Vesalius" without emotion:

"Vesalius," says Mr. Hallam, in his History of the Literature of Europe, "left every anatomist far behind. He was to anatomy what Copernicus was to astronomy. A superstitious prejudice against human dissections had restrained ancient anatomists in general to pigs and apes. Vesalius and his students prowled by night in charnel-houses, they dug up the dead, they climbed the gibbet, in fear and in silence, to steal the mouldering carcase of the murderer, the risks of ignominious punishment, and the secret stings of superstitious remorse, exalting, no doubt, the delight of those useful but not very enviable pursuits. Being absurdly accused of having dissected a Spanish gentleman *before he was dead*, Vesalius only escaped capital punishment, at the instance of the Inquisition, by undertaking a pilgrimage to Jerusalem, during which he was shipwrecked, and died of famine in one of the Greek Islands" (in the year 1563). The only proof against Vesalius was, that the young nobleman's heart *moved* (some say palpitated) when it was exposed to view by dissection. This motion was doubtless nothing more than some contractions of the muscular fibres excited by the knife (as already explained), and which may be produced in every heart recently dead, without, perhaps, a single exception. Having digressed so far, I will add that, some years since, several medical students declared to me that, while dragging an extremely large, yellow fever subject from one room to another, preparatory to dissection, the *cadaver* groaned distinctly. I arrived soon after—I found the contractile function very strong. Venesection discharged blood with force upward, against the principles of gravity, and in great quantity—(a curious subject, upon which I have the materials for a monograph). The circumstances alluded to appeared wholly inexplicable, until, at length, I heard a subject groan with my own ears,—since which I have caused many groans by placing the foot against the chest, and making strong pressure, which causes the air to be expelled through the larynx and organs of speech with noises sometimes not unlike difficult breathing and inarticulate moaning. The elasticity of the ribs causes them to return to their former state, as soon as the pressure is withdrawn; the air at the same time rushes through the opening of the glottis to fill up the vacuum in the chest.

In most biographies of Vesalius, it is said that, after he had dissected down to the heart, this organ was found palpitating with life! This nobleman, be it observed, had been the patient of Vesalius, had died under his eyes, and *showed no signs of life during the early part of the dissection*, and before the exposure of the heart—the friends of the de-

ceased had requested the post-mortem examination, and did not, it may be inferred, proceed prematurely. The operator had long before published the greatest work on Anatomy that the world had ever seen (*De Corporis Humani Fabricâ*), and must have known what were the signs of death. From all these circumstances it may be inferred that the accusation upon which the Inquisition condemned him to the most cruel tortures and death, and from which Charles V. saved him, was absurd in the highest degree, and originated in that post-mortem contraction above described.*

The tales now circulated, chiefly by some European writers, going to show that not a few persons have been buried alive, or have shown signs of life after the phenomena supposed to belong to real death had taken place, may have no better foundation in most cases, than that upon which Vesalius was exiled. It is, moreover, to be observed that the most cele brated writers upon this subject, and upon premature interment, seem to get their facts from reports and rumors not properly authenticated. Even M. Julia de Fontenelle, who has written elaborately upon this subject, seems not to have seen any of the cases which he has collected from all points of the compass, chiefly from the newspapers. Such facts afford at best

"A most lame and impotent conclusion,"

which must be productive of evil only, by arraying the strongest prejudice against the progress of science and the increase of human happiness.

I beg leave to add the following observations, suggested by an examination of the last American edition of Bell's Anatomy and Physiology, made since the above essay was written. In the articles entitled, "*The Muscular Power—The Discoveries of the Author*," etc., will be found the statements following: "The key to the system—is, each filament or track of nervous matter" [whether from the anterior or posterior portions of the spinal cord] "has throughout its whole length, its peculiar endowment; if its office be sensation, when injured, sensation, not motion, will result;"—that portion of the "ulnar nerve formed of the anterior root of the spinal nerve, in all its extent constitutes one organ, and ministers to one function, the activity of the muscle of the hand and finger."—"The nerves have all the power of exciting motion."—But, when he comes to speak of a muscle's quivering and moving after its separation from the body, he is sorely puzzled. He does not, like Dr. Hall, pretend that the mere introduction of a probe into the spinal mar

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* It appears from the Boston Medical Journal, for January, 1846, that a Dr. Waterman, of Buffalo, N. Y., has been sentenced to hard labor for three years, in the State Prison, for *disinterring* a dead body for dissection! Has the age of Vesalius returned? Is it a crime to increase human happiness by increasing human knowledge, its indispensable element? Shall the worms on land and the sharks at sea, be entrusted with the whole knowledge of Anatomy? Is that true philanthropy which seeks to save the ravisher and murderer from capital punishment, that he may be placed in prison side by side with an honest man, whose only crime consists in operating on the dead, that he may know how to operate on the living with safety? The Quack is privileged to kill with impunity! Will he be in haste to change his ways—to become a good citizen—that is, to get a knowledge of his profession, when the punishment of a felon is to be the reward of his pains?

row will cause the muscles to become "instantly flaccid, non-resilient, shapeless" (an expression too strong for imagination itself), "and non-contractile." Sir Charles attempts to account for the contraction: but in so doing, he completely nullifies, nay, destroys, his own theory of anterior roots, as well as its reflex addition, both root and branch. "There can be," says he, "no separation of the muscular and nervous systems —the nerves meet everywhere with the muscular fibre." Here, then, is a fine piece of logic! The anterior tract of the spinal cord gives out the anterior roots, which are the sole agents of motion! But when the arm is separated from the body, then the motion is performed, not at the origin, but at the extremities of the nerves, which belong to the biceps, for example! This is as good as an unconditional surrender. I offer but one argument more, and I appeal to a candid world if it be not conclusive against the doctrines of Bell and Hall. In striking the biceps muscle, in the manner I have described, nearly all the great nervous cords distributed to the arm, fore-arm, wrist, hand, and fingers, are equally the recipients of the percussing force, as the external cutaneous, the median, etc. Now, the same force that is applied to the nervous twigs of the biceps, ought to communicate motion to all the parts upon which the great nerves ramify; that is, to the fore-arms and fingers. This never happens in the slightest degree; the motion is limited to the muscle struck, and not transmitted to the muscles to which the nerves are distributed.

In a word, the London experiments were made upon the roots—the New Orleans experiments upon the terminations of the nerves; the former were few, it would seem, and were upon inferior animals—the latter were numerous and upon man. In London the contractions were feeble, "though perceptible to the naked eye"—in New Orleans they were powerful, carrying heavy weights during flexions and extensions against gravity and against a leverage of great force; upon the whole exceeding the former as much as the Mississippi River exceeds the Thames.

In making these statements I indulge a hope (an illusion, it may be) that critics, whether from contempt, or charity, or justice to the writer of this monograph, will perform the experiments herein mentioned, before animadverting too strongly upon its doctrines. The experiments are easily performed. Is it right to throw the great reputation of my opponents in the scale against my facts? In such a case, laboring as I do *con amore*, whilst every capital in Europe swarms with salaried professors, who are teaching neurological doctrines quite opposite, the *argumentum ad hominem* is unworthy of Mrs. Caudle herself. It is precisely the great reputation of our masters which, as history teaches, is likely to impede the march of science in many instances.

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## APPENDIX.

I have, this day (Feb. 9th, 1846), for the first time seen Dr. Marshall Hall's Memoirs on the Nervous System (4to., plates, pp. 113, London)—being somewhat later than his lectures upon the same subject as quoted above, and differing in nothing but a slight re-marshalling of sections and sub-sections. No one can regret more than I to speak of a writer so

justly distinguished (independent of any reflex theory) as Dr. Hall, in any other terms than commendation, but as his experiments seem to have a bearing more or less in conflict with mine, I must run the risk of being charged with temerity, if not arrogance, in the cause of what I suppose to be the truth ; this may not be good policy, but it is at least honest and warranted by the occasion. I rely fully on the authenticity of his facts (many of which have probably no application to the physiology of man). I only differ from him in their interpretation and value. At page 112 of the above named work, he gives what he emphatically calls a recapitulation of "The *whole of his discoveries*;" "*discoveries*," as he declares, "*entirely due to him.*" Such statements, involving priority of discovery, may often seem sterile to the reader, but they are not necessarily either unreasonably selfish or egotistic, but come under the golden rule which "renders to Cæsar that which is Cæsar's." "First discovery ; the *distinction* of the excito-motory property from sensation, volition, instinct, and all the functions of the cerebrum or mind." Now, is not this an assumption, implying (possibly truly) that when the head is chopped off, sensation, volition, and the entire mind, are completely chopped off likewise? Ignorant as we are in such matters, until some decapitated gentleman shall arise from the grave to explain further concerning the feelings and the motions of his headless trunk, what can be gained by subdividing all the muscular actions in this same trunk, after "the amputation of the encephalic extremity," which, a learned author informs us very gravely, "cannot be done in the living subject without stopping respiration and producing other inconveniences, which under the operation are happily inadmissible." "Second discovery ; the *distinction* of this property from the *vis insita*, or irritability of the muscular fibre." Is not this a distinction without a difference—one that runs through all of Dr. Hall's books on the reflex theory? He labors hard—and it were easy to show unsuccessfully—to prove that his doctrine has nothing to do with the old discovery of irritability ; yet he has everywhere admitted that they may and do exist simultaneously. That vague mass of phenomena designated by the *vis insita* has been baptized under another name ; a theoretical name which implied no theory, where no theory is available. Repudiating the *vis insita*, he claims for the reflex function ; "the principle of equilibrium and tone in the whole muscular system, and the principle which presides over the orifices and sphincters of the internal canals"—(p. 38) ;—all of which, according to him, cease as soon as the spinal cord is disintegrated, leaving the muscles "*lax, flaccid, without resiliency, shapeless*" (*passim*)—none of which, I will add, ever happens with human cadavera, in lat. 29° 67′ N., long. 90° 7′ W. ; though I cannot speak for the meridian of Greenwich, long. 0°, lat. 51° 29′ N. "Third, the *distinction* of this property as a function of the spinal marrow. Fourth, the *identification* of the excito-motory property with the motor power exercised by the spinal marrow. Fifth, the excito-motory property acts in an *incident, retrograde*, and *reflex course*, when stimulated mechanically or by galvanism, or by the natural stimuli in the living animal." "These," he adds, "are *all* the points certainly and entirely due to him."

"The spinal cord is the sole organic seat of this reflex function, and in an especial manner of the emotions, passions, and appetites" (pp. 96, 71). Let psychologists who have the care and cure of souls, and

phrenologists, who perform the same offices for our cranial bumps, consider this matter well. Mr. G. Combe has mapped off thirty-five phrenological organs; two reflective, twelve perceptive, leaving no less than twenty-one for the passions, propensities and sentiments—all absorbed by the spinal marrow, according to Dr. Hall,—a goodly number, seeing their unruly character and unfortunate location, to use an Americanism. Dr. Hall might as well claim all Oregon as all the emotions and passions for the spine. Phrenology sustained itself with difficulty in upper realms of intellection, but, with more ease as soon as it dipped its wing in the lower, the animal, the philoprogenitive, the amative, the cerebellar territories. The reflex science, as if by enchantment, transfers the whole of the passions and the mysteries of generation to the spinal region, throwing, at least, a suspicion upon the stability of human knowledge; though Dr. Hall maintains that his "*System is scarcely liable to error; its originality is obvious.*"—(P. 53.) "Day follows night, and night the dying day,"—not a pleiad has ever wandered from the constellation of Taurus, while medical systems disappear like the banks of the Mississippi, which often shoot noiselessly away, with house and builder many a fathom below the turbid waves. *Sic transit gloria mundi.*

Dr. Hall has given a number of plates or maps, exhibiting, not the phrenological regions, nor yet the fantastic travels of a delirious dreamer, but the devious windings, and marchings, and counter-marchings of this romantic reflex potentate, the veritable Don Quixote of physiology. Contraction by percussion in the manner I have described, would be wholly excluded from irritability, as defined by Dr. H., who says, "The movements of irritability are the result of the *immediate application* of a stimulus to the nervo-muscular fibre *itself*."—(P. 31.) I affirm, that a blow on the skin with an intervening layer of fat an inch or more thick, is as effectual, perhaps more so, in exciting contractions than one *immediately laid on the naked fibres themselves.*

There may be some convenience, if not philosophy, in dividing muscular contractility into voluntary, involuntary, and mixed—but to divide it into psychical, galvanic, cerebral, reflex, vital, irritable, and the like, with a view to establish species of a scientific character, to tally separate and different from each other, is perfectly idle. Since the metaphysics of Neurology can furnish nothing better, let us appeal to common sense for an illustration. The personator of the melancholy Hamlet, for example, in speaking of

> The heart-ache, and the thousand natural shocks
> That flesh is heir to,—

would probably put his hand on his breast. The next day the tragedian falls sick of a cardiac disease, and puts his hand to the same place to point out a physical ache. The day following, being comatose and insensible, he probably places his hand in the same way. He dies. I strike the biceps, and as in the tragedy, as in the sickness, he carries his hand to his breast. Here many circumstances have changed—muscular action is modified; yet who will prove that this action itself is not essentially the same in nature, though excited differently? Haller would say—Vis insita!—C. Bell, Anterior roots!—Hall, Reflex action!—The electricians, electricity! galvanism!—The vitalists, vitality!—The che-

mists, chemistry! Omitting the third flexion in this series, the two first are such as would be denominated *psychical*, because excited by the mind, and the last would be called by some other name, according to the operator's theory; but in neither case do we know whether the essential nature of both be the same or different; and we deceive ourselves in supposing that the name explains the thing. If the post-mortem contraction were called *stickical*, because excited by a stick, it would be a good an explanation of the phenomena, as to call the ante-mortem cons traction *psychical*. A celebrated physician, so the story runs, in finishing a course of lectures on muscular motion, said, "Gentlemen, I have told you all that is known upon this subject, and now, if you understand one jot of the cause of muscular motion, you know more than I do."

It is not intended on this occasion to say anything upon the *materializing* tendency of neurological speculations of the day, though it would not be difficult to show that there is some credulity, not to say fanaticism, in proclaiming that the feeling, thinking, willing, hoping, fearing, deserving, conscious entity, called the *mind*, is identical with its gross organs, whether muscular or nervous, spinal or cerebral. And as to its *locale*, it may not be altogether philosophical to advocate the exclusive claim of the back, or the stomach, or the heart, or the head. The sooner another Thomas Reid shall appear with his massive logic to destroy the snags and obstructions which are choking up the stream of mental philosophy, the better it will be, likewise, for physiology in general, and more especially for that part of it—*now the larger half*—which is claimed for the spinal cord—"*the sole seat of all the emotions, passions, and appetites!*" according to the Reflex School.